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Izzo

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(54) **VALVE ASSEMBLY WITH A GUIDE ELEMENT**

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F02M 61/12	(2006.01)
F02M 51/06	(2006.01)
F02M 61/18	(2006.01)

(52) **U.S. Cl.**

CPC ***F02M 61/12*** (2013.01); ***F02M 51/061*** (2013.01); ***F02M 51/0625*** (2013.01); ***F02M 51/0671*** (2013.01); ***F02M 61/1806*** (2013.01); *Y10S 239/90* (2013.01)

(58) **Field of Classification Search**

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USPC 239/585.1, 585.4, 585.5, 533.11, 533.12, 239/900

See application file for complete search history.

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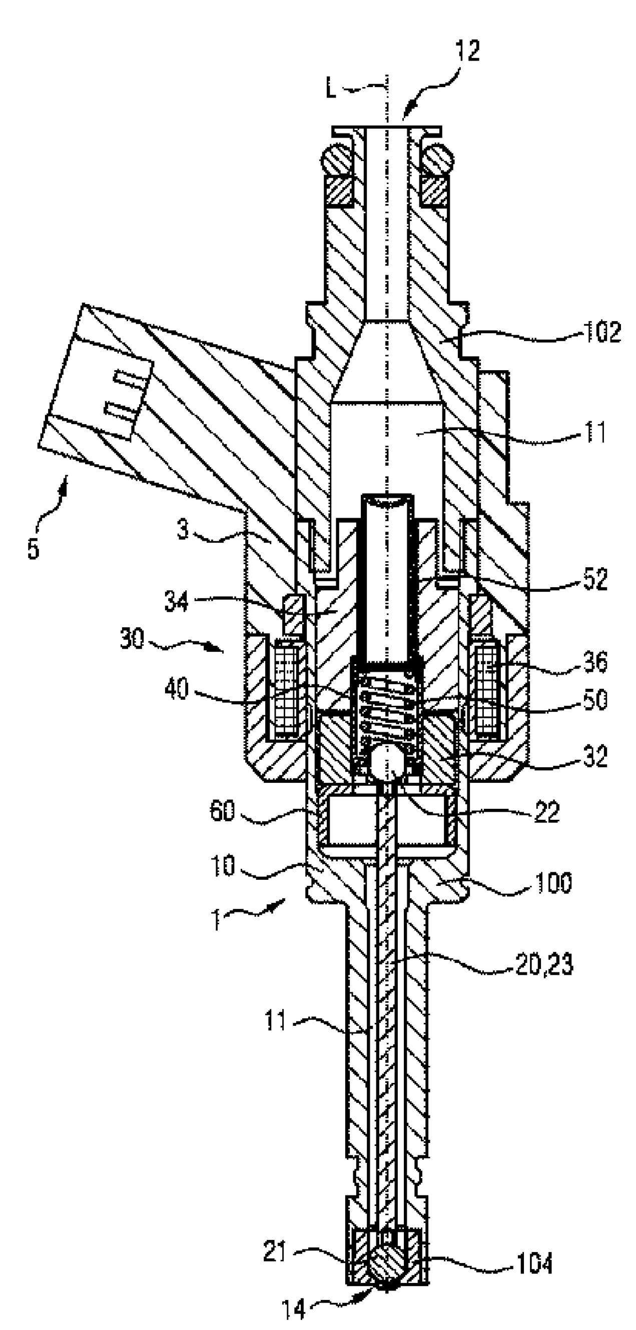
(57) **ABSTRACT**

A valve assembly for a fluid injection valve contains a hollow valve body which hydraulically connects a fluid inlet to an injection orifice and has a longitudinal axis. A valve needle is received in the valve body in an axially displaceable fashion for sealing the injection orifice in a closing position. An electromagnetic actuator assembly is provided for displacing the valve needle away from the closing position, the actuator assembly containing a movable armature and a pole piece which is positionally fixed relative to the valve body. A guide element is positionally fixed relative to the pole piece, has a first guide surface for axially guiding the armature and a second guide surface for axially guiding the valve needle.

19 Claims, 7 Drawing Sheets



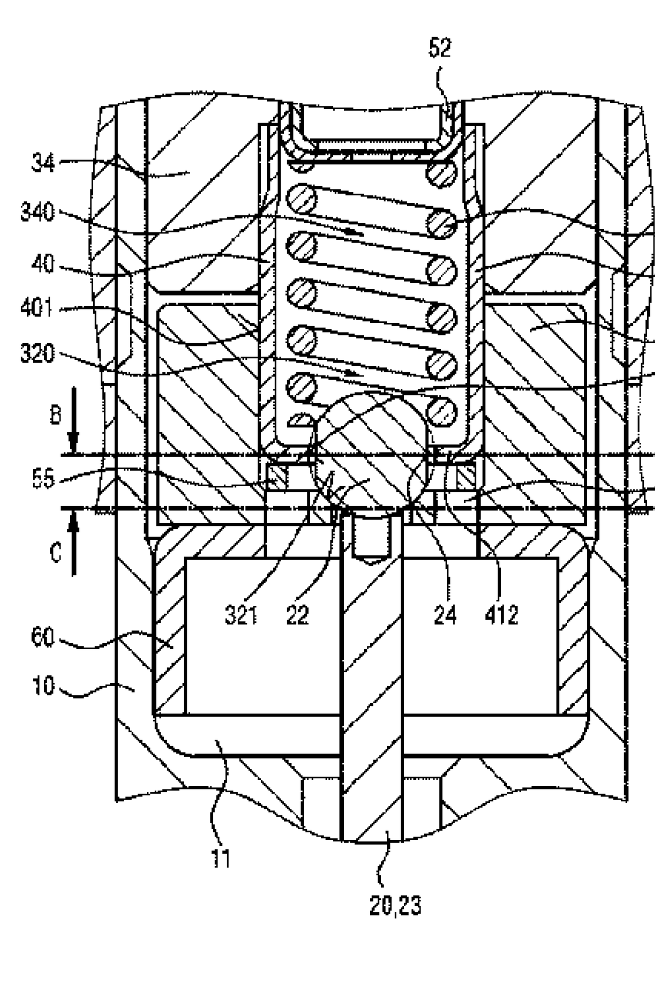


FIG 1

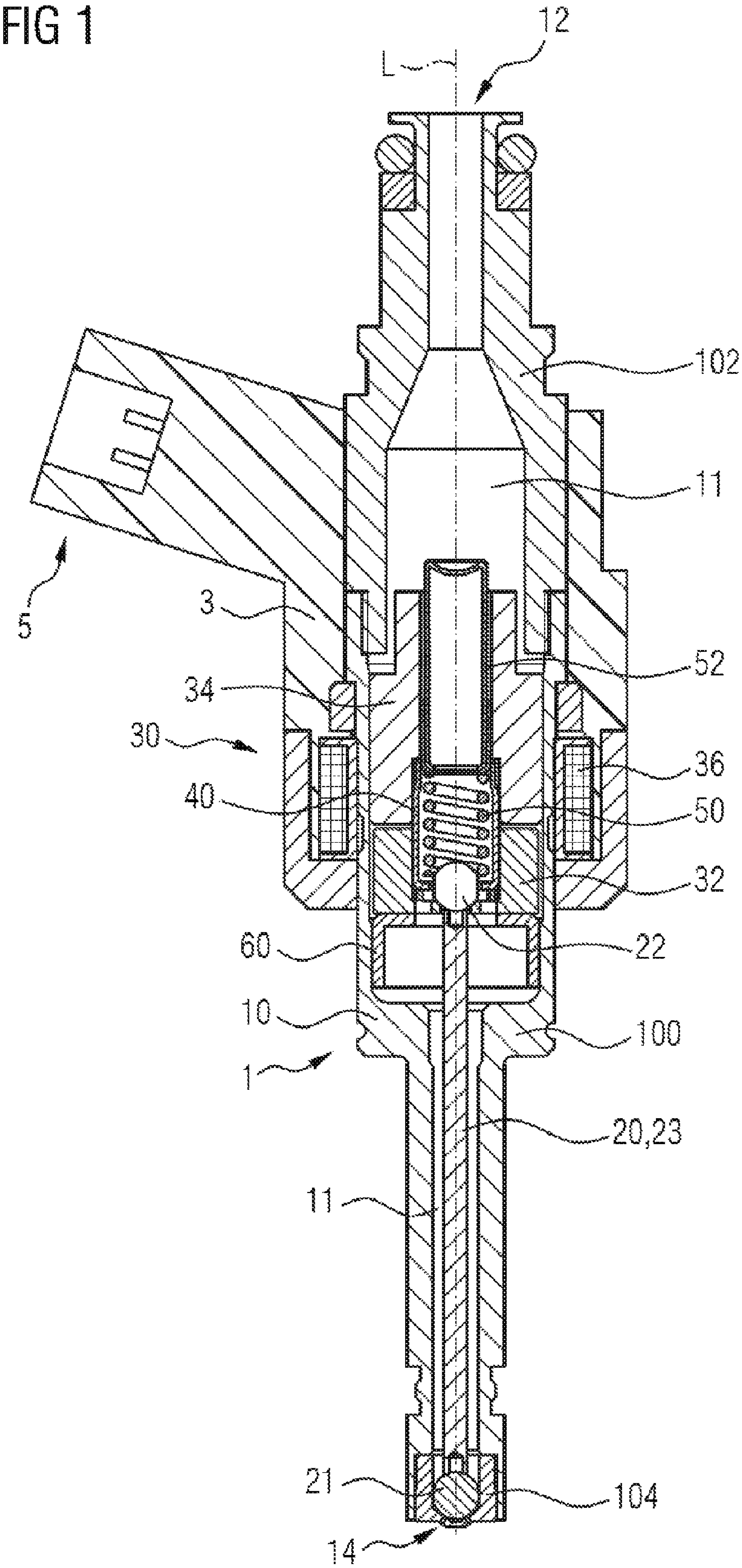
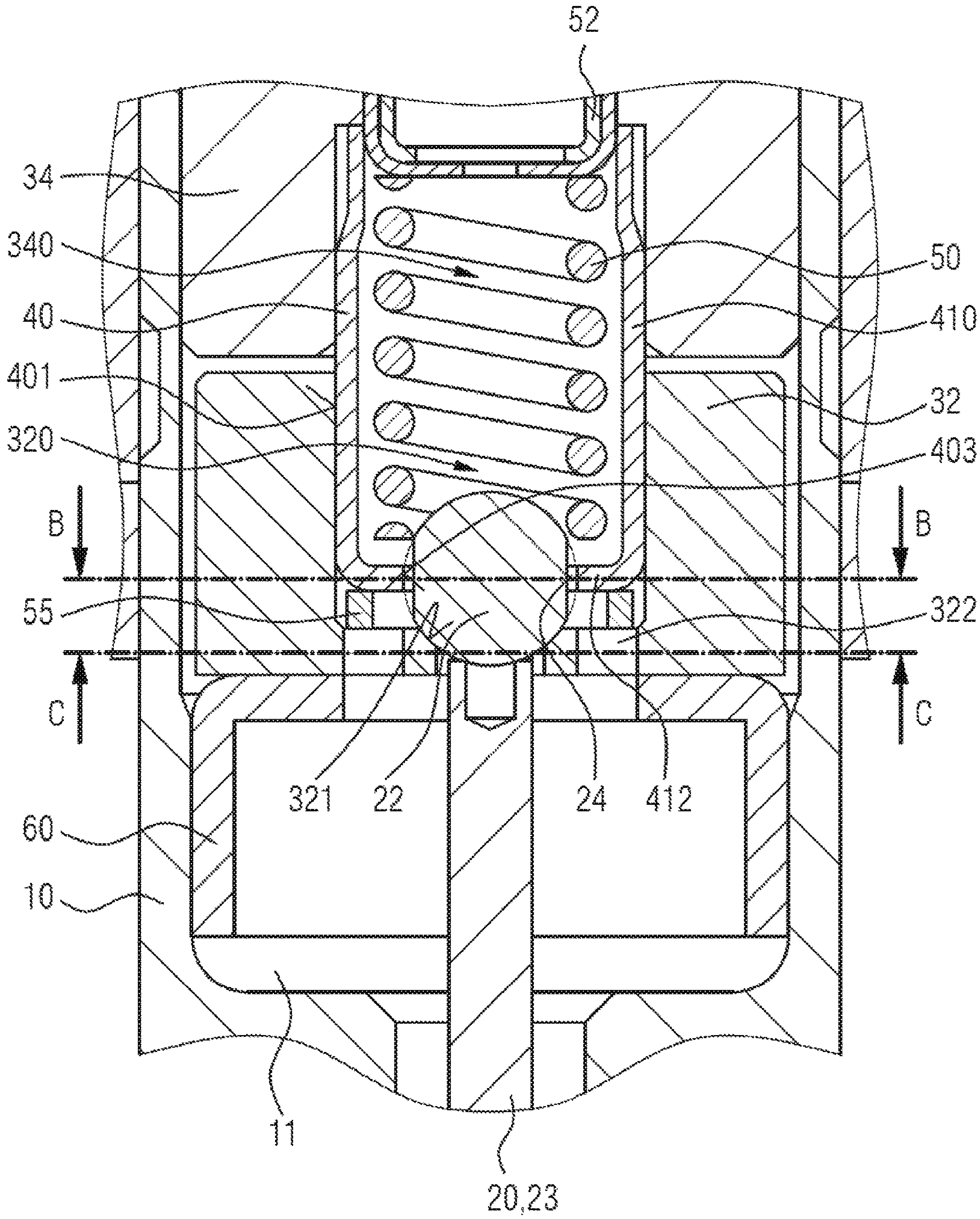


FIG 2A


52
34
340
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401
320
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410
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403
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321
22
24
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60
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11
20,23

FIG 2B

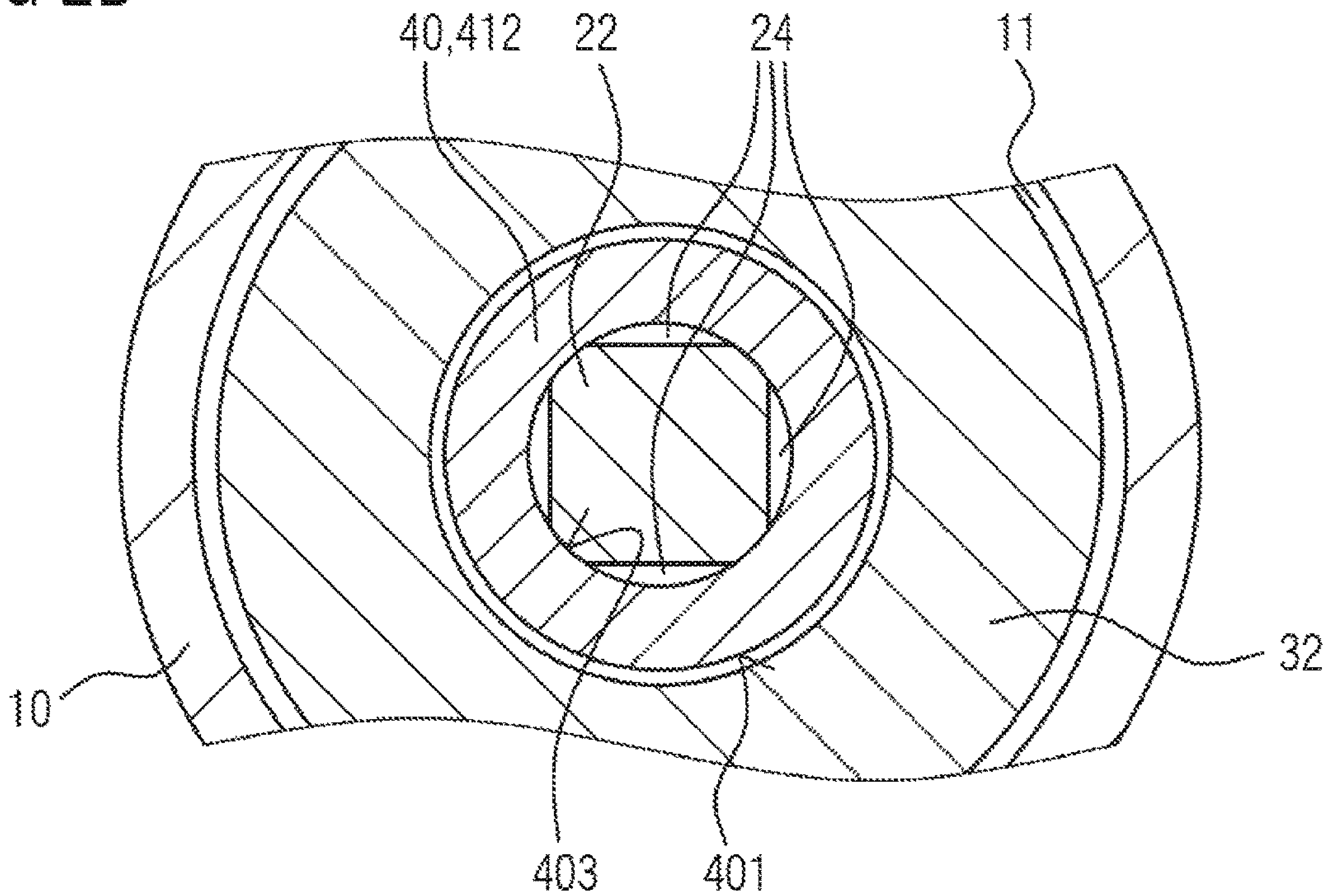


FIG 2C

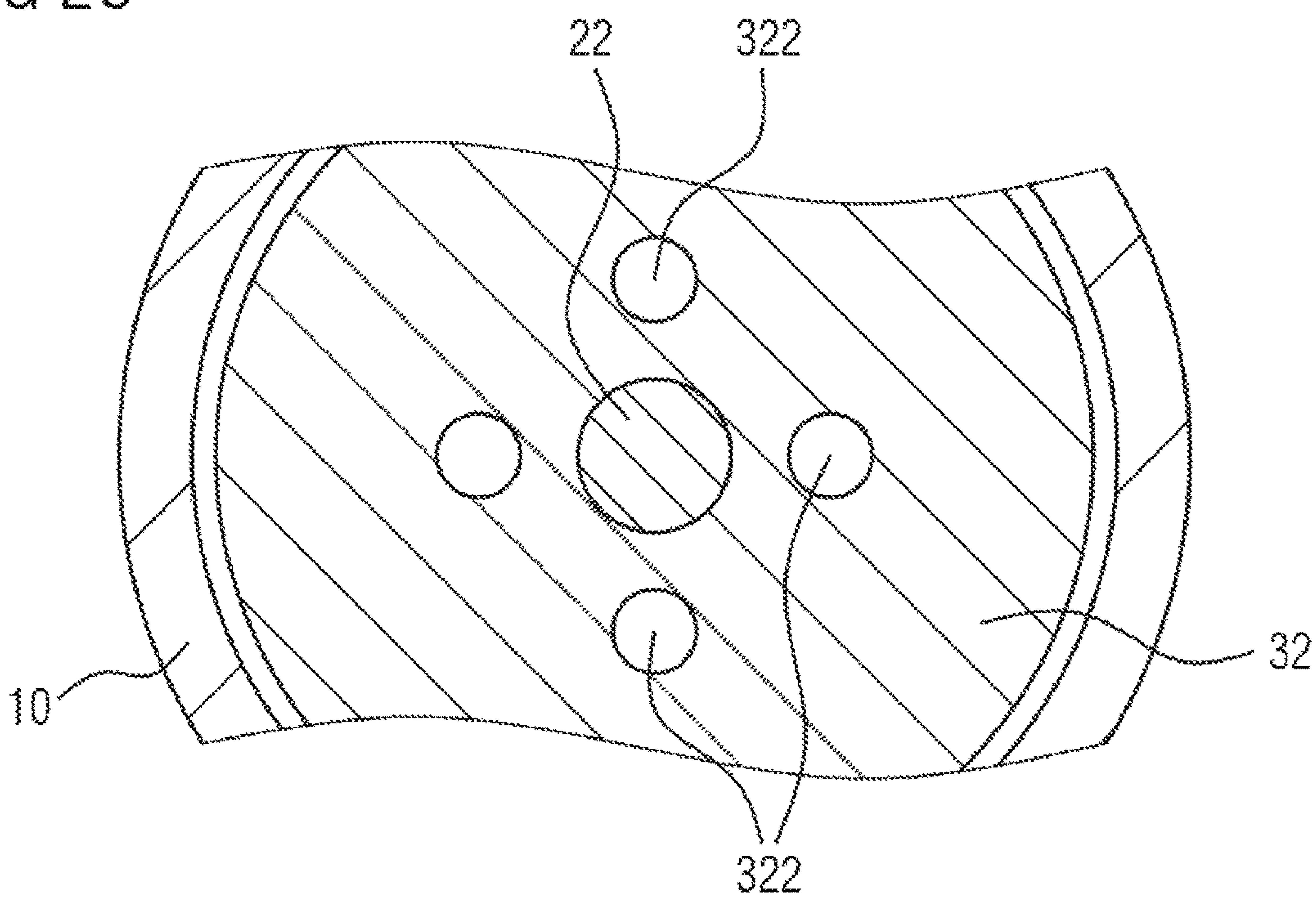


FIG 3A

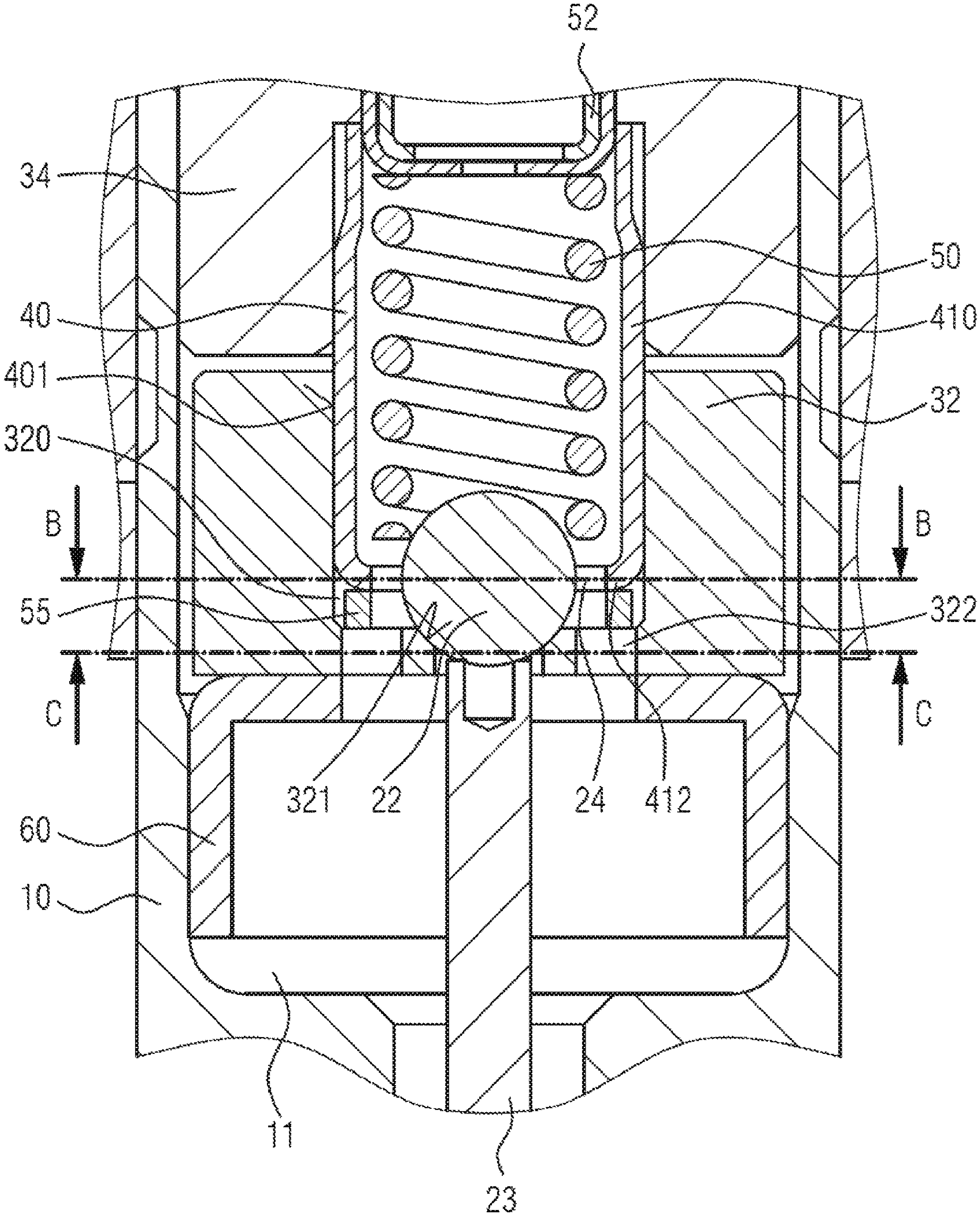


FIG 3B

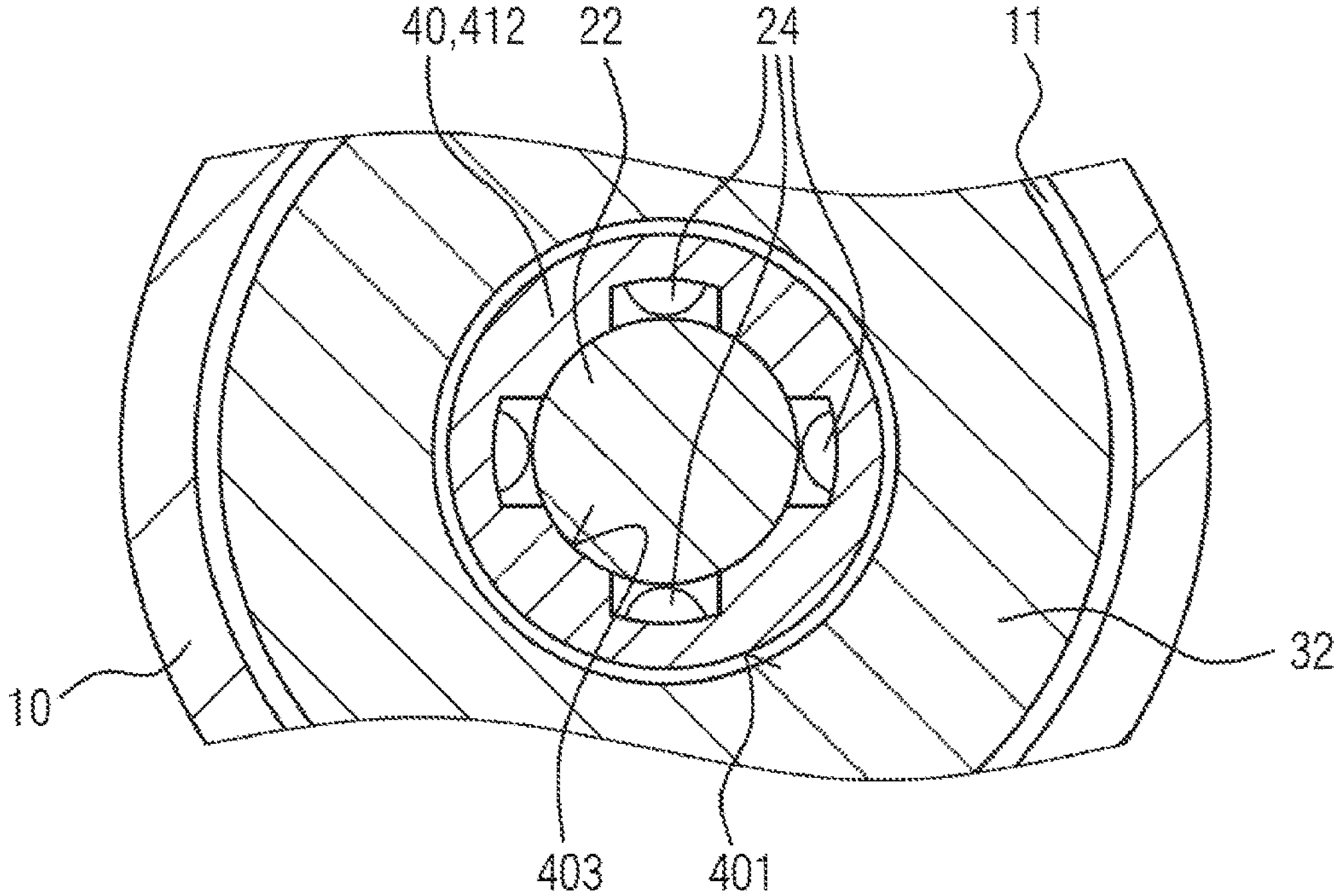


FIG 3C

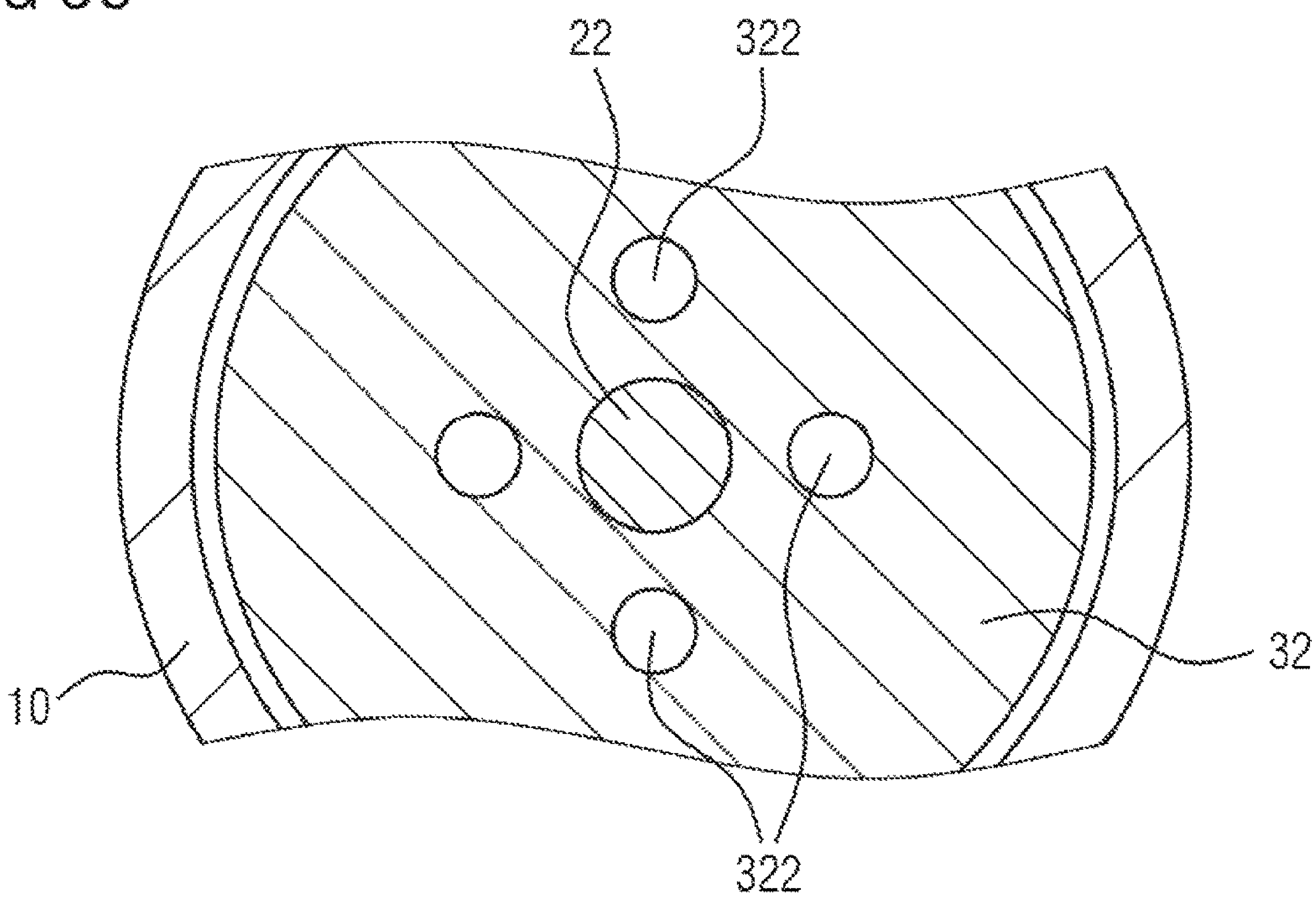
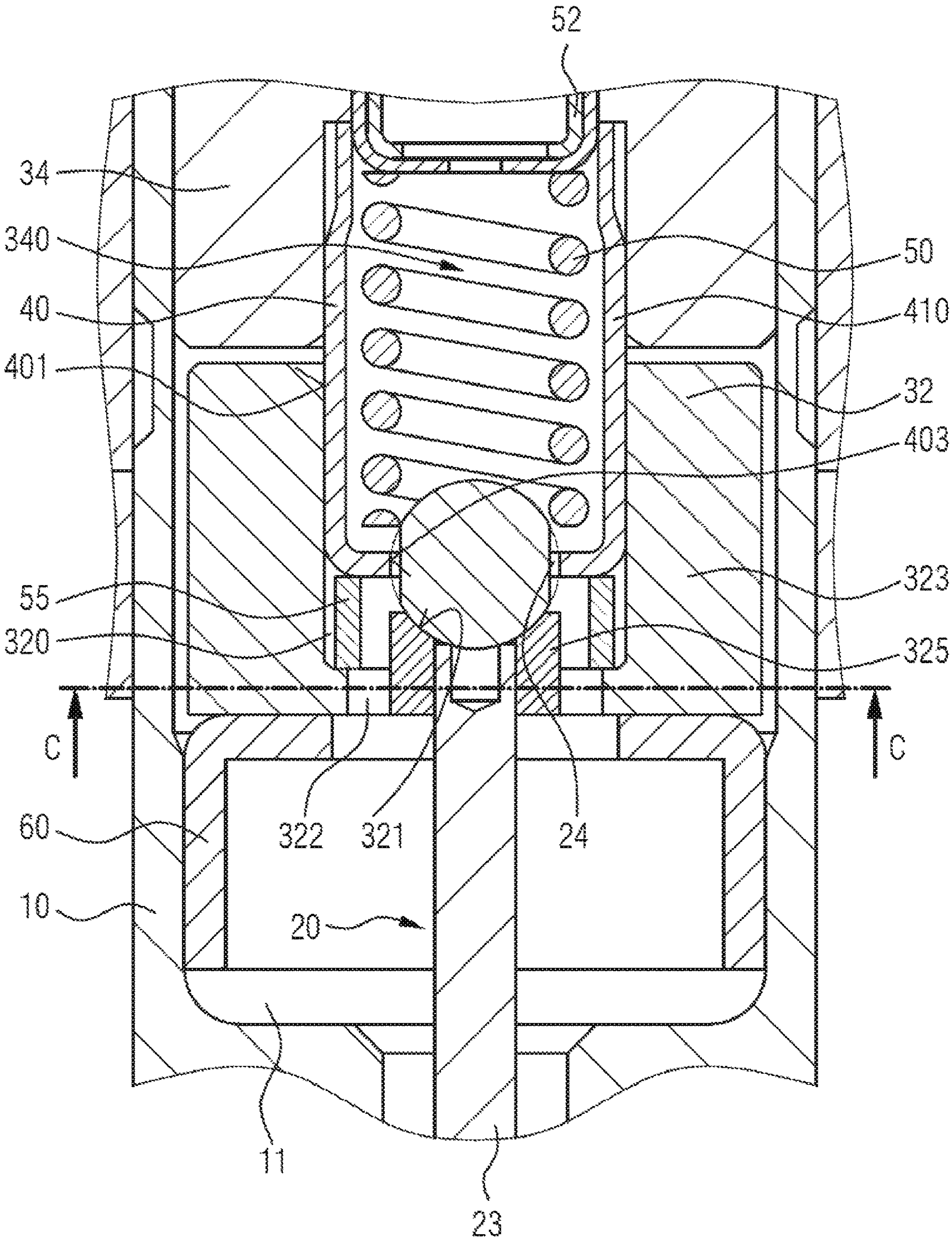


FIG 4A


52
34
340
40
401
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410
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403
323
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325
C
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322
321
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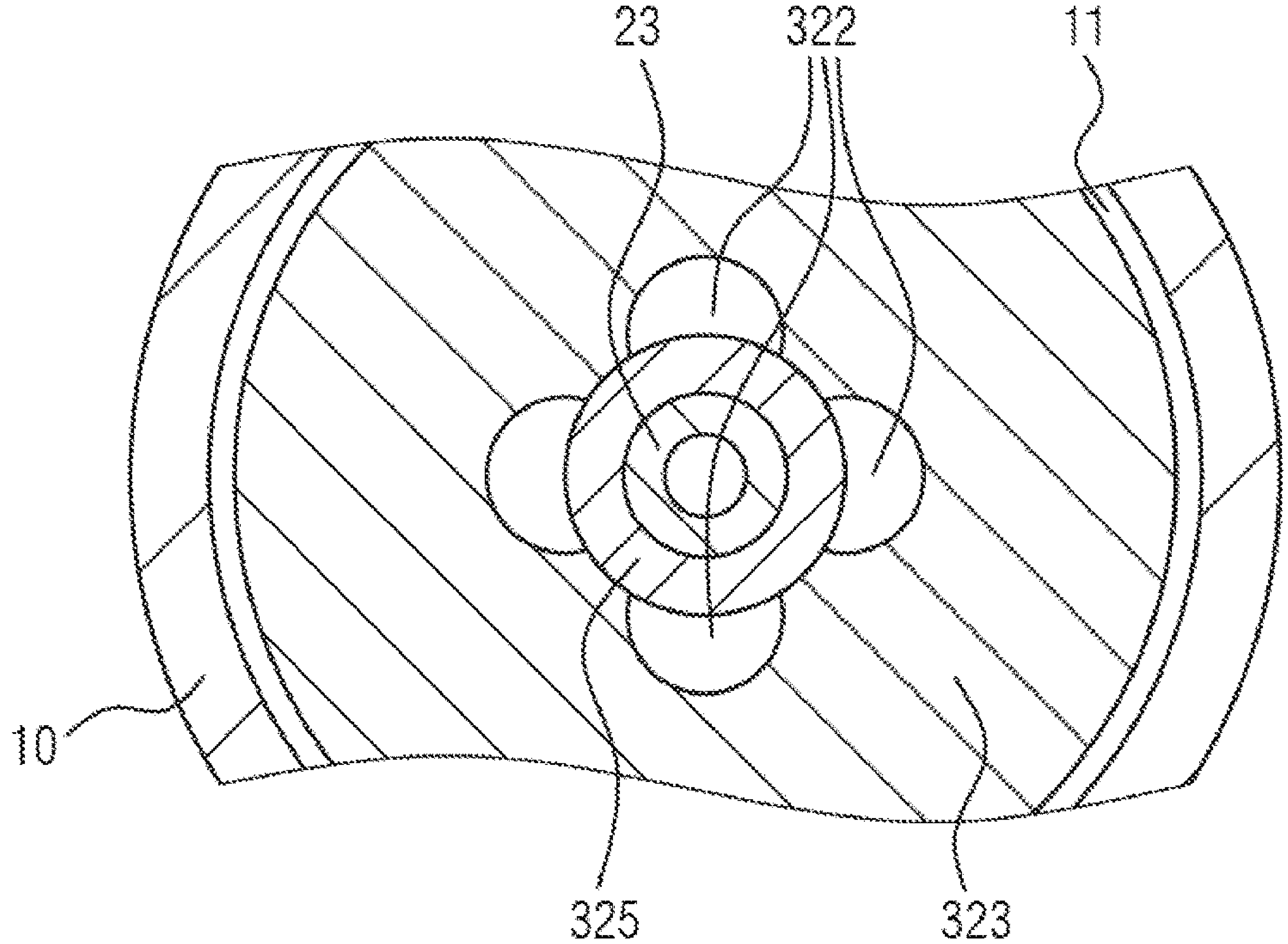
11
23

FIG 4B



VALVE ASSEMBLY WITH A GUIDE ELEMENT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority, under 35 U.S.C. §119, of European patent application EP 15156485, filed Feb. 25, 2015; the prior application is herewith incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present disclosure relates to a valve assembly with a guide element for a fluid injection valve and to a fluid injection valve.

Fluid injection valves are used, for example, for injecting fuel into combustion chambers of internal combustion engines. Part-to-part and shot-to-shot variations of the injection characteristic of the fuel injectors have detrimental influence on fuel consumption and pollutant emission of the engine. Such variations may be introduced by manufacturing tolerances and in particular by long tolerance chains among several components.

SUMMARY OF THE INVENTION

It is an object of the present disclosure to provide an improved valve assembly for a fluid injection valve, enabling in particular comparatively small variations of the injection characteristic between different injection events and between different injectors of the same type.

According to one aspect, a valve assembly for a fluid injection valve is specified. According to a further aspect, a fluid injection valve containing the valve assembly is specified.

The valve assembly contains a hollow valve body which hydraulically connects a fluid inlet to one or more injection orifices and has a longitudinal axis. In particular, the valve body extends from the fluid inlet to the fluid outlet. The valve body may be closed at the fluid outlet except for the injection orifice(s), for example by a seat element of the valve body which is positioned at the fluid outlet and contains the injection orifice(s). For the sake of simplicity, the valve assembly may only be described in connection with one injection orifice in the following. However, the present disclosure also encompasses valve assemblies having a plurality of injection orifices.

The valve assembly further contains a valve needle which is received in the valve body. The valve needle is axially displaceable relative to the valve body in reciprocating fashion. The valve needle is configured for sealing the injection orifice in a closing position and for unsealing the injection orifice in other positions. In other words, the valve needle mechanically interacts with the valve body—in particular with the seat element—for sealing and unsealing the injection orifice. Expediently, the valve needle is in sealing contact with the seat element in the closing position and is axially displaceable away from the closing position to establish a gap between the valve needle and the seat element to enable fluid flow through the injection orifice.

Further, the valve assembly contains an electromagnetic actuator assembly for displacing the valve needle away from the closing position. The actuator assembly contains an armature and a pole piece. The pole piece is positionally fixed relative to the valve body while the armature is movable in reciprocating fashion relative to the pole piece and, thus, to the valve body. Preferably, the actuator assembly further contains a magnetic coil for generating a magnetic field to attract the armature towards the pole piece.

Further, the valve assembly contains a guide element which is positionally fixed relative to the pole piece. The guide element has a first guide surface for axially guiding the armature and a second guide surface for axially guiding the valve needle.

In this way, a particularly simple and precise guiding of the armature and the valve needle is achievable. In particular, a particularly precise parallel arrangement of impact surfaces of the armature and the pole piece—the impact surfaces of the armature and the pole piece facing towards and other and preferably being in mechanical contact in the fully open configuration of the valve assembly—is achievable by the guide element. Additional tolerances, for example by axially guiding the armature via the valve needle, can be avoided. Therefore, a particularly precise positioning of the valve needle relative to the armature may be unnecessary in case of the valve assembly of the present disclosure. Rather, both the valve needle and the armature are guided directly by the positionally fixed guide element.

In an expedient embodiment, the first and second guide surfaces are perpendicular to the mutually facing impact surfaces of the armature and the pole piece. Such perpendicular arrangement is particularly easily and precisely achievable with the valve assembly according to the present disclosure. The parallelism of the mutually facing impact surfaces of the armature and the pole piece is independent of manufacturing tolerances relating to the valve needle.

In one embodiment, the pole piece has a central axial opening in which the guide element is partially arranged and from which the guide element projects. In this way, a particularly precise positioning of the guide element and, consequently, of the armature relative to the pole piece is achievable.

In one embodiment, the guide element is in the shape of a sleeve, the first and second guide surfaces being comprised by an outer circumferential surface and an inner circumferential surface of the sleeve, respectively. The valve assembly may be configured such that fluid flows from the fluid inlet to the injection orifice through the sleeve. In one development, the guide element has a generally cylindrical outer surface and the first guide surface is represented by a portion of the cylindrical outer surface which projects from the pole piece. In another development, the guide element has a cylindrical shell, extending along the longitudinal axis with its cylindrical axis parallel to the longitudinal axis, and a lid portion extending radially inward from this cylindrical shell at one axial end thereof, in particular at that axial end which projects from the pole piece. The lid portion has an aperture in which a portion of the valve needle is received. A circumferential surface of the aperture may expediently represent the second guide surface. In this way, particularly precise guiding and/or particularly cost-effective manufacturing of the guide element are achievable.

In one embodiment, the valve needle contains a retainer element. The retainer element and the armature are operable to engage in a form-fit connection for displacing the valve needle away from the closing position. In one development, the retainer element mechanically interacts with the second guide surface of the guide element for axially guiding the valve needle. Preferably, the retainer element projects radially beyond a shaft of the valve needle. By means of the retainer element together with the guide element, a particularly precise axial guiding of the valve needle is achievable.

In particular, the retainer element of the valve needle and the lid portion of the guide element overlap in axial direction. Preferably, the retainer element has a curved shape at least in the region where it mechanically interacts with the guide element for axially guiding the valve needle. In this way, the risk that the retainer element and the guide element get jammed is particularly small.

In one embodiment, the armature retainer element has a spherical basic shape and the armature has a conical contact surface for engaging with the retainer element. In this way, the connection between the valve needle and the armature is particularly insensitive to manufacturing tolerances, in particular with respect to a tilt between the valve needle and the armature. At the same time, a curved surface of the retainer element for interacting with the guide element is achieved.

In one embodiment, the armature contains a main part and a bushing. The bushing and the main part are preferably made from different materials. In particular, the bushing is made from a material which is harder than the material from which the main part is made. The bushing may expediently be positioned radially between the valve needle and the main part in some places. The bushing preferably contains a contact surface of the armature—in particular the conical contact surface—which is in contact with the valve needle, in particular with the retainer element, for transferring a force to the valve needle to displace the valve needle away from the closing position.

In an expedient embodiment, at least one fluid channel is formed between the retainer element and the guide element. In one development, the aperture of the lid portion has a circular contour in top view along the longitudinal axis while the retainer element has a generally spherical basic shape provided with flats or axially extending recesses to establish gaps between the lid portion and the retainer element which represent fluid channels. In another development, the retainer element has a spherical shape—i.e. without flats or recesses in the region which axially overlaps the lid portion—while the lid portion contains the cutouts which extend axially through the lid portion for establishing fluid channels.

In one embodiment, the armature has a central recess. The guide element may in particular project axially from the pole piece into the central recess. A circumferential surface of the recess may expediently interact with the first guide surface of the guide element for axially guiding the armature. In one development, the retainer element is arranged in the central recess and the guide element is positioned radially between the retainer element and the armature at least in the region of the second guide surface. In this way, a particularly precise guiding of the armature and the valve needle is achievable. In the above context, "in the region of the second guide surface" refers in particular to those portions of the retainer element, the guide element, and the armature which have the same coordinates on the longitudinal axis as the second guide surface.

In one embodiment, the valve assembly further contains a calibration spring for biasing the valve needle towards the closing position. In one development, the calibration spring is at least partially arranged in the guide element, in particular in embodiments in which the guide element is in the shape of a sleeve. In a further development, one axial end of the calibration spring is seated against the retainer element. In particular in the case of the retainer element having a spherical basic shape, the calibration spring may advantageously be self-centering relative to the valve needle. An axial end of the calibration spring facing away from the valve needle may be seated against the calibration tube, which is preferably shifted into the central axial opening of the pole piece and, particularly preferably, connected thereto by a force-fit connection.

In another embodiment, the valve assembly contains an armature spring for biasing the armature away from the pole piece. In an expedient development, the armature spring is positioned in the recess of the armature and seated against the armature and the guide element at its opposite axial ends. In a further development, the armature spring is operable to move the armature out of contact with the retainer element when the valve needle is in the closing position so that the armature, when it is moving towards the pole piece, has to cover a so-called free lift before establishing the form fit connection with the retainer element and taking the valve needle with it.

In a further embodiment, the valve assembly further contains an armature stopper. In one embodiment, the armature stopper is generally disc shaped and has a central opening through which the valve needle extends. Preferably, it is distanced from the valve needle.

The armature stopper is arranged in the hollow valve body on the side of the armature remote from the pole piece. It is positionally fixed relative to the valve body. For example, it has a tubular portion on its side remote from the armature for establishing a form-fit connection and/or a force-fit connection and/or a welded connection with the valve body.

The armature stopper is operable to limit axial displacement of the armature away from the pole piece. In one development, the armature spring is configured for biasing the armature into contact with the armature stopper when the electromagnetic actuator assembly is de-energized.

In one development, the armature stopper is configured for hydraulically damping movement of the armature of a from the pole piece. For example, the armature stopper and the armature each have impact surfaces which face towards another, which are parallel, and which have an overlapping area of at least 25% of the cross-sectional area of the cavity of the valve body in the region of the impact surfaces. A particularly precise parallel orientation of the impact surfaces is achievable with the valve assembly according to the present disclosure. In particular, the parallelism of the impact surfaces of the armature and the armature stopper is independent from manufacturing tolerances relating to the valve needle. The parallelism between the impact surface of the pole piece—coming in contact with the armature in a fully open configuration of the valve assembly—and of the armature stopper—coming in contact with the armature in a closed configuration of the valve assembly—may be particularly precise due to the arrangement and fixation of the armature stopper and the guide element. Tolerances of the orientation of these surfaces may greatly influence the hydraulic damping of the armature and, thus lead to shot-to-shot and part-to-part deviations of the injected fluid quantity.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a valve assembly with a guide element, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. **1** is a diagrammatic, longitudinal sectional view of a fluid injection valve having a valve assembly according to a first exemplary embodiment of the invention;

FIG. **2**A is a longitudinal sectional view of a detail of the valve assembly according to the first embodiment;

FIG. **2**B is a cross-sectional view of the valve assembly according to the first embodiment;

FIG. **2**C is a further cross-sectional view of the valve assembly according to the first embodiment;

FIG. **3**A is a longitudinal sectional view of a detail of a valve assembly according to a second embodiment;

FIG. **3**B is a cross-sectional view of the valve assembly according to the second embodiment;

FIG. **3**C is a further cross-sectional view of the valve assembly according to the second embodiment;

FIG. **4**A is a longitudinal sectional view of a detail of the valve assembly according to a third embodiment; and

FIG. **4**B is a cross-sectional view of the valve assembly according to the third embodiment.

DETAILED DESCRIPTION OF THE INVENTION

In the exemplary embodiments and figures, similar, identical or similarly acting elements are provided with the same reference symbols. In some figures, individual reference symbols may be omitted to improve the clarity of the figures.

Referring now to the figures of the drawings in detail and first, particularly to FIG. **1** thereof, there is shown a longitudinal section view of a fluid injection valve. The fluid injection valve, in the present exemplary embodiment, is a fuel injection valve which is configured for injecting fuel—such as gasoline—directly into a combustion chamber of an internal combustion engine.

The fuel injection valve contains a valve assembly **1** according to a first exemplary embodiment. A portion of the valve assembly **1** is shown in more detail in the longitudinal section view of FIG. **2**A and in the cross-sectional views of the planes IIB-IIB (FIG. **2**B) and IIC-IIC (FIG. **2**C) which are indicated in FIG. **2**A.

The valve assembly **1** has a hollow valve body **10** which extends along a longitudinal axis L and hydraulically connects a fluid inlet **12** at one axial end of the valve body **10** to one or more injection holes **14** at the opposite axial end of the valve body **10**. In particular, the valve body **10** has a cavity **11** extending in axial direction through the valve body **10** for leading fluid from the fluid inlet **12** to the injection hole(s) **14**. Only for the sake of simplicity, the embodiment will be described below in connection with only one injection hole **14**.

In the present embodiment, the valve body **10** is assembled from a plurality of parts, in particular from a main body **100**, a fluid inlet tube **102** and a seat element **104**. The fluid inlet tube **102** includes the fluid inlet **12** and the seat element **104** includes the injection hole **14**. In an alternative embodiment (not shown in the figures), the seat element **104** may be in one piece with the main body **100**.

A valve needle **20** is received in the cavity **11** of the valve body **10**, in particular it is arranged in the main body **100**. The valve needle includes a sealing element **21** and a retainer element **22** at opposite axial ends. A shaft **23** of the valve needle extends from the sealing element **21** to the retainer element **22**.

The sealing element **21** is positioned adjacent to the seat element **104**. In a closing position of the valve needle **20**, the sealing element **21** is in sealing mechanical contact with a valve seat—which is comprised by the seat element **104** in the present embodiment—for preventing fluid flow through the injection hole **14**, i.e. for sealing the injection hole **14**. In the present embodiment, the sealing element **21** has a spherical basic shape and is a separate part which is fixed to the shaft **23**. Other designs are also conceivable, for example the sealing element **21** could be represented by a tip of the shaft **23**. The sealing element **21** and the seat element **104** are in sliding mechanical contact—in particular in a region upstream of the valve seat—for axially guiding the valve needle **20** adjacent to its downstream axial end.

The valve needle **20** is axially displaceable in reciprocating fashion relative to the valve body **10** in the cavity **11**. In particular, it is axially displaceable away from the closing position to establish a gap between the valve seat and the sealing element **21**, i.e. to unseal the injection hole **14**.

The valve assembly **1** contains an electromagnetic actuator assembly **30** for displacing the valve needle **20** away from the closing position. The electromagnetic actuator assembly **30** contains a pole piece **34** which is positioned in the cavity **11** of the valve body **10** and connected thereto, for example by a force-fit connection, so that it is positionally fixed relative to the valve body **10**. Alternatively, it is also conceivable that the pole piece **34** is in one piece with one part of the valve body **10**.

The electromagnetic actuator assembly **30** further contains a movable armature **32**. The armature **32** is positioned in the cavity **11** adjacent to the pole piece **34** and movable relative to the pole piece **34** and the valve body **10** in reciprocating fashion.

In addition, the actuator assembly **30** has a magnetic coil **36**. The magnetic coil **36** is operable to generate a magnetic field when the actuator assembly **30** is energized. By the magnetic field, the actuator assembly **30** is operable to displace the armature **32** axially towards the pole piece **34**. The coil **36** is positioned outside of the valve body **10** and surrounds a portion thereof. It may be positioned in a coil housing and embedded in a molded plastic housing **3** of the fluid injection valve. The plastic housing **3** preferably contains an electrical connector **5** for feeding electrical power to the coil **36**.

The armature has a central recess **320**. The retainer element **22** of the valve needle **20** is positioned in the central recess **320**. The central recess **320** has a bottom surface which is perforated by a through-hole in the armature **32**. The shaft **23** of the valve needle **20** extends through the through-hole and projects beyond the armature **32**, in the present embodiment in direction towards the sealing element **21**. The retainer element **22** projects radially beyond the through-hole so that the retainer element **22** and the bottom surface of the recess **320** are operable to engage in a form-fit connection for displacing the valve needle **20** away from the closing position.

In the present embodiment, the retainer element **22** has a spherical basic shape and the recess **320**, in a region adjacent to the through-hole, has a conical contact surface **321** for engaging with the retainer element **22**. In this way, by means of the sphere-to-cone interface, the form-fit connection between the retainer element **22** and the armature **32** is particularly insensitive to a tilt of the valve needle **20** relative to the armature **32**.

The valve assembly **1** further contains a calibration spring **50** which is seated against the retainer element **22** and against a calibration tube **52** on opposite axial sides. The calibration tube **52** is fixed to the valve body **10**—in the present embodiment it is positioned in a central axial opening **340** of the pole piece **34**. It is connected to the pole piece **34** by a force-fit connection. In the present embodiment, the calibration tube **52** contains a filter element for filtering the fuel on its way through the cavity **11** from the fluid inlet end **12** to the injection orifice **14**.

The calibration spring **50** is preloaded by the calibration tube **52** for biasing the valve needle **20** towards the closing position. When the coil **36** is energized, the actuator assembly **30** is operable to move the valve needle **20** axially away from the closing position against the bias of the calibration spring **50** by an axial movement of the armature **32** towards the pole piece **34** and the mechanical interaction of the armature **32** with the valve needle **20** via the retainer element **22**. The axial movement of the armature **32** is stopped when mutually facing impact surfaces of the armature **32** and the pole piece **34** engage into a form-fit engagement.

In order to guide the axial movements of the valve needle **20** and the armature **32**, the valve assembly **1** contains a sleeve-shaped guide element **40**. The guide element **40** is positionally fixed relative to the pole piece **34** and, thus, to the valve body **10**. It is positioned in the central axial opening **340** of the pole piece **34** and axially projects from the central axial opening **340** on the side of the pole piece **34** which faces towards the armature **32** in such fashion that the guide element **40** axially overlaps the armature **32** and the valve needle **20**.

Expediently, the central axial opening **340** may have a step on which the guide element **40** bears. The axial position of the guide element **40** may reproducibly be defined in a simple way during manufacturing the valve assembly **1**. The guide element **40** is in particular fixed to the pole piece **34** by a form-fit connection and/or a force-fit connection and/or a welded connection.

At least a portion of the calibration spring **50** is arranged inside the sleeve-shaped guide element **40** in the present embodiment. In the present embodiment, the guide element **40** and the calibration tube **52** project from the pole piece **34** on opposite axial sides. In particular the guide element **34** and the calibration tube **52** are shifted into the central axial opening **340** from opposite axial sides of the pole piece **34**.

The sleeve-shaped guide element **40** has a cylindrical shell **410** and a lid portion **412**. The cylindrical shell **410** extends along the longitudinal axis L with its cylindrical axis coaxial to the longitudinal axis L. The lid portion **412** extends radially inward from the cylindrical portion **410** at that axial end of the cylindrical shell **410** which projects from the pole piece **34**.

The guide element has a first guide surface **401** for axially guiding the armature **32** and a second guide surface **403** for axially guiding the valve needle **20**. In other words, the first guide surface **401** is in sliding contact with the armature **32** and the second guide surface **403** is in sliding contact with the valve needle **20**.

The cylindrical shell **410** of the guide element **40** is partially arranged in the central axial opening **340** of the pole piece **34**. It projects axially from the pole piece **34** and into the recess **320** of the armature **32**. For axially guiding the armature **32**, a circumferential section of the cylindrical outer surface of the cylindrical shell **410** overlaps axially with the recess **320** and mechanically interacts with an inner circumferential surface of the armature **32**, the inner circumferential surface defining the recess **320**. Thus, the first guide surface **401** is represented by the circumferential section of the cylindrical outer surface of the cylindrical shell **410** in the present embodiment.

The first guide surface **401** and the inner circumferential surface of the recess **320** are parallel to the longitudinal axis and perpendicular to the mutually facing impact surfaces of the armature **32** and the pole piece **34**. In this way, a parallel arrangement of the impact surfaces is achieved.

The lid portion **412** axially overlaps the retainer element **22**. More specifically, the lid portion **412** has an aperture which extends through the lid portion **412** in axial direction and in which at least a portion of the retainer element **22** is positioned. A cylindrical circumferential surface of the lid portion **412** which faces radially inward and defines the aperture mechanically interacts with the curved surface of the retainer element **22** for axially guiding the valve needle **20** and, thus, represents the second guide surface **403**. In the region of the second guide surface **403**, the guide element **40**—in particular its lid portion **412**—is positioned radially between the retainer element **22** and the armature **32**. To put it differently, in the region of the second guide surface **403**, the retainer element **22**, the guide element **40** and the armature **32** follow one another in this order in radial outward direction.

As can be seen best in FIG. 2B, the retainer element **20** deviates from a completely spherical shape in that it is provided with flat surface regions which are parallel to the longitudinal axis L. The aperture of the lid portion **412** of the guide element **40**, on the other hand, has a circular contour in top view along the longitudinal axis L, so that by means of the flat surface regions fluid channels **24** are formed between the retainer element **22** and the guide element **40**.

Further fluid channels **322** are provided in the armature **32**. Preferably, the further fluid channels **322** perforate the bottom surface of the recess **320**. In the present embodiment, the further fluid channels **322** are laterally spaced apart from the through-hole through which the shaft **23** of the valve needle **20** projects from the armature **32** (see FIG. 2C).

In this way, a fluid path through the cavity **11** of the valve body **10** is established, such that the fluid is led from the inlet tube **102** through the filter element into the calibration tube **52**, through the calibration tube **52**, and further into the guide element **40**. From the interior of the guide element **40**, the fluid is led further through the fluid channels **24** between the guide element **40** and the retainer element **22** into the recess **320** of the armature **32** and from there through the further fluid channels **322** to the injection hole **14**.

When the actuator assembly **30** is de-energized, the calibration spring **15** is operable to move the valve needle **20** into the closing position. The valve needle **20**, on its way to the closing position, takes the armature **32** with it via the form fit connection with the retainer element **22**. The valve assembly **1** is configured such that the armature **32** can move further away from the pole piece **34** when the valve needle **20** impacts the valve seat as it enters into the closing position. The valve assembly **1** contains an armature stopper **60** for limiting the further movement of the armature **32** by a form fit engagement.

The armature stopper **60** is fixed to the valve body **10**, for example by a force-fit connection and/or form-fit connection and/or a welded connection. The armature stopper **60** is positioned on the side of the armature **32** remote from the pole piece **34**. The armature stopper **60** is spaced apart from the valve needle **20**, i.e. it is not in mechanical contact with the valve needle **20**. In this way, fluid can pass the armature stopper **60** through a gap between the armature stopper **60** and the valve needle **20** on its way from the fluid inlet **12** to the injection hole **14**.

In order to decelerate the movement of the armature **32** away from the pole piece **34** by means of hydraulic damping, the armature **32** and the armature stopper **60** have mutually facing impact surfaces which are parallel to one another, perpendicular to the longitudinal axis L, and have an overlapping area which has a size of at least 30% of the cross-sectional area of the cavity **11** at the axial position of the impact surfaces.

An armature spring **55** is arranged in the recess **320** of the armature **32**. It is seated against the bottom surface of the recess **320** and against the lid portion **412** of the guide element **40** on opposite axial sides. The armature spring **55** is preloaded to bias the armature **32** away from the pole piece **34**, out of contact with the retainer element **22**, and into contact with the armature stopper **60** when the valve needle **20** is in the closing position and the actuator assembly **30** is de-energized.

FIGS. **3**A, **3**B, and **3**C show a second exemplary embodiment of the valve assembly **1** in a longitudinal section view corresponding to that of FIG. **2**A and in cross-sectional views corresponding to those of FIGS. **2**B and **2**C.

The valve assembly **1** according to the second exemplary embodiment corresponds in general to the valve assembly **1** according to the first embodiment. However, in the present embodiment the fluid channels **24** between the guide element **40** and the retainer element **22** are not realized by means of flat surface regions of the retainer element **22**. Rather, the retainer element **22** has a spherical shape without flats, so that it has a circular outer contour in the cross-sectional view of FIG. **3**B. Instead, the fluid channels **24** are formed by means of cutouts in the lid portion **412** of the guide element **40**, the cutouts extending axially through the lid portion **412**.

A valve assembly **1** according to a third exemplary embodiment is shown in FIGS. **4**A and **4**B. The valve assembly **1** according to the third embodiment corresponds in general to the valve assembly **1** of the first embodiment. The longitudinal sectional view of FIG. **4**A corresponds in general to the longitudinal sectional view of FIG. **2**A and the cross-sectional view of FIG. **4**B in the plane IVB-IVB which is shown in FIG. **4**A corresponds in general to the cross-sectional view of FIG. **2**C.

While the armature **32** is a one-piece element in the first exemplary embodiment, it contains a main part **323** and a bushing **325** in the present embodiment. The bushing **325** is positioned radially between the valve needle **20** and the main part **323** in some places. For example, the main part **323** contains the recess **320** and the bushing **325** extends through the bottom surface of the recess **320** for defining the through-hole through which the valve needle **20** axially extends. In particular, the conical contact surface **321** is comprised by the bushing **325** in the present embodiment. The further fluid channels **325** may, for example, be formed by cutouts in the main part **323** at the interface of the main part **323** with the bushing **325**.

Expediently, the bushing **325** consists of a harder material than the main part **323** of the armature **32**. In this way, undesirable wear at the form fit connection between the retainer element **22** and the bushing **325** may be particularly small.

The invention is not limited to specific embodiments by the description on basis of these exemplary embodiments. Rather, it contains any combination of elements of different embodiments. Moreover, the invention comprises any combination of claims and any combination of features disclosed by the claims.

The invention claimed is:

1. A valve assembly for a fluid injection valve, the valve assembly comprising:

a fluid inlet;

an injection orifice;

a hollow valve body hydraulically connecting said fluid inlet to said injection orifice and having a longitudinal axis;

a valve needle received in said valve body in an axially displaceable fashion for sealing said injection orifice in a closing position and unsealing said injection orifice in other positions;

an electromagnetic actuator assembly for displacing said valve needle away from the closing position, said electromagnetic actuator assembly having a movable armature and a pole piece being positionally fixed relative to said hollow valve body; and

a guide element positionally fixed relative to said pole piece, said guide element having a first guide surface for axially guiding said movable armature and a second guide surface for axially guiding said valve needle;

said guide element being in a shape of a sleeve having an outer circumferential surface and an inner circumferential surface, said first and second guide surfaces being comprised by said outer circumferential surface and said inner circumferential surface of said sleeve, respectively.

2. The valve assembly according to claim **1**, wherein said pole piece has a central axial opening formed therein and in which said guide element is partially disposed and from which said guide element projects.

3. The valve assembly according to claim **1**, wherein:

said valve needle has a retainer element, said retainer element and said movable armature are operable to engage in a form-fit connection for displacing said valve needle away from the closing position; and

said retainer element mechanically interacts with said second guide surface of said guide element for axially guiding said valve needle.

4. The valve assembly according to claim **3**, wherein said retainer element has a spherical basic shape and said movable armature has a conical contact surface for engaging with said retainer element.

5. The valve assembly according to claim **3**, further comprising at least one fluid channel being formed between said retainer element and said guide element.

6. The valve assembly according to claim **3**, wherein:

said movable armature has a central recess formed therein;

said retainer element is disposed in said central recess;

said guide element projects axially from said pole piece into said central recess; and

said guide element is positioned radially between said retainer element and said movable armature at least in a region of said second guide surface.

7. The valve assembly according to claim **1**, wherein said movable armature has a main part and a bushing, said bushing is positioned radially between said valve needle and said main part in some places, and said bushing having a conical contact surface.

8. The valve assembly according to claim **1**, further comprising:

a calibration spring for biasing said valve needle towards the closing position; and an armature spring for biasing said movable armature away from said pole piece.

9. The valve assembly according to claim 1, further comprising an armature stopper being disposed in said hollow valve body on a side of said movable armature remote from said pole piece, being positionally fixed relative to said hollow valve body and operable to limit axial displacement of said movable armature away from said pole piece.

10. A fluid injection valve, comprising:

a valve assembly, said valve assembly including:

a fluid inlet;

an injection orifice;

a hollow valve body hydraulically connecting said fluid inlet to said injection orifice and having a longitudinal axis;

a valve needle received in said hollow valve body in an axially displaceable fashion for sealing said injection orifice in a closing position and unsealing said injection orifice in other positions;

an electromagnetic actuator assembly for displacing said valve needle away from the closing position, said electromagnetic actuator assembly having a movable armature and a pole piece which is positionally fixed relative to said hollow valve body; and

a guide element positionally fixed relative to said pole piece, said guide element having a first guide surface for axially guiding said movable armature and a second guide surface for axially guiding said valve needle;

said guide element being in a shape of a sleeve having an outer circumferential surface and an inner circumferential surface, said first and second guide surfaces being comprised by said outer circumferential surface and said inner circumferential surface of said sleeve, respectively.

11. A valve assembly for a fluid injection valve, the valve assembly comprising:

a fluid inlet;

an injection orifice;

a hollow valve body hydraulically connecting said fluid inlet to said injection orifice and having a longitudinal axis;

a valve needle received in said valve body in an axially displaceable fashion for sealing said injection orifice in a closing position and unsealing said injection orifice in other positions;

an electromagnetic actuator assembly for displacing said valve needle away from the closing position, said electromagnetic actuator assembly having a movable armature and a pole piece being positionally fixed relative to said hollow valve body; and

a guide element positionally fixed relative to said pole piece, said guide element having a first guide surface for axially guiding said movable armature and a second guide surface for axially guiding said valve needle;

wherein said pole piece has a central axial opening formed therein and in which said guide element is partially disposed and from which said guide element projects.

12. The valve assembly according to claim 11, wherein said pole piece has a central axial opening formed therein and in which said guide element is partially disposed and from which said guide element projects.

13. The valve assembly according to claim 11, wherein:

said valve needle has a retainer element, said retainer element and said movable armature are operable to engage in a form-fit connection for displacing said valve needle away from the closing position; and

said retainer element mechanically interacts with said second guide surface of said guide element for axially guiding said valve needle.

14. The valve assembly according to claim 13, wherein said retainer element has a spherical basic shape and said movable armature has a conical contact surface for engaging with said retainer element.

15. The valve assembly according to claim 13, further comprising at least one fluid channel being formed between said retainer element and said guide element.

16. The valve assembly according to claim 13, wherein:

said movable armature has a central recess formed therein;

said retainer element is disposed in said central recess;

said guide element projects axially from said pole piece into said central recess; and

said guide element is positioned radially between said retainer element and said movable armature at least in a region of said second guide surface.

17. The valve assembly according to claim 11, wherein said movable armature has a main part and a bushing, said bushing is positioned radially between said valve needle and said main part in some places, and said bushing having a conical contact surface.

18. The valve assembly according to claim 11, further comprising:

a calibration spring for biasing said valve needle towards the closing position; and

an armature spring for biasing said movable armature away from said pole piece.

19. The valve assembly according to claim 11, further comprising an armature stopper being disposed in said hollow valve body on a side of said movable armature remote from said pole piece, being positionally fixed relative to said hollow valve body and operable to limit axial displacement of said movable armature away from said pole piece.

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